TITLE OF THE INVENTION

SCANNING EXPOSURE APPARATUS AND METHOD

FIELD OF THE INVENTION

The present invention relates to an exposure apparatus and method for exposing a pattern formed on a master such as a reticle onto a substrate such as a wafer in a photolithography process for manufacturing a semiconductor element, liquid crystal display element,

10   or the like and, more particularly, to a scanning exposure method and apparatus of a step-and-scan scheme in which the master and substrate are synchronously scanned while part of a pattern on the master is projected onto the wafer, so that the pattern of the

15   master is sequentially transferred to the shot regions on the substrate.

BACKGROUND OF THE INVENTION

In a conventional photolithography process for

20   manufacturing, e.g., a semiconductor element, liquid crystal display element, image sensing element (e.g., a CCD), or thin-film magnetic head, a cell projection exposure apparatus such as a stepper has been used in which a pattern formed on a master such as a reticle is

25   exposed onto a substrate such as a wafer coated with a photosensitive material.

In recent years, semiconductor device chips tend

to increase in size, and a pattern having a larger area on a reticle must be exposed onto a wafer. A projection exposure apparatus of a step-and-scan scheme is frequently used because it can expose an area larger

5   than the irradiation field (pattern exposure region in a stationary state) of a projection optical system by synchronously scanning the reticle and wafer.

A cell projection exposure apparatus repeats operation of stepping the shot region of an exposure

10   object to the irradiation field, operation of aligning the shot region and reticle, and exposure operation for the shot region.

In a scanning projection (step-and-scan scheme) exposure apparatus, however, a wafer stage is stepped

15   to the scanning start position of the next shot region. The wafer stage and a reticle stage are scanned from the scanning start position to accelerate them so that they reach predetermined scan speeds at the exposure start position. The relative positions of the reticle

20   stage and wafer stage are set with high alignment accuracy. Exposure light irradiation is started to perform scanning exposure by driving the reticle stage and wafer stage at the predetermined scan speed.

Upon completing scanning exposure of one shot,

25   stepping operation to the next shot in the non-scan direction is started, and at the same time the wafer stage is scanned in the scan direction by a necessary

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distance in order to set the wafer stage before the start of scanning exposure. The wafer stage is then decelerated. Upon completing scanning in the scan direction, the scan direction is reversed, and then

5 scanning exposure of the next shot is started. The series of operations described above are repeated. The setting distance necessary before the start of scanning exposure is obtained by the product of the scan speed and the time (setting time) required until the

10 vibration generated upon accelerating the wafer stage falls within the allowable range in which the vibration does not interfere with exposure.

At present, the setting time is the sum of a margin and a value obtained by measuring a

15 synchronization error from the end of acceleration and measuring a time until this error falls within the allowable range.

In the conventional scanning projection exposure apparatus, the synchronization setting time of the

20 reticle stage and wafer stage at the time of scanning exposure is determined on the basis of the sum of the margin and the setting time measured beforehand, i.e., on the basis of the worst setting time value. In actual exposure, however, a time within which the

25 synchronization accuracy falls within the allowable range may be shorter than the conventionally used setting time due to factors such as an exposure speed,

acceleration, hardware factors, and slight differences in thrust of a linear motor coil serving as a driving source of the wafer stage due to driving coordinate values of the wafer stage. Even in this case, since

5 the setting distance is determined on the basis of the worst setting time value at present, the scan distance is wasted, and an increase in throughput cannot be achieved.

10 SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above situation, and has as its object to shorten the total time required for maintaining synchronization accuracy and improve the

15 throughput by variably setting a setting distance serving as a distance for moving a wafer stage at a uniform velocity in order to guarantee that synchronization error between a master stage and the substrate stage falls within an allowable range.

According to the present invention, the foregoing object is attained by providing a scanning exposure apparatus for transferring a pattern of a master onto each shot region while synchronously scanning the master and a substrate on which a plurality of shot

25 regions are arrayed, comprising: a master stage for moving the master; a substrate stage for moving the substrate; and a controller for controlling movement of

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the substrate stage over a plurality of shot regions so as to assure a setting distance serving as a distance for scanning and moving the substrate stage at a uniform velocity in order to guarantee that

5 synchronization error between the master stage and the substrate stage falls within an allowable range after the substrate stage is accelerated up to a scan speed for scanning exposure, wherein the controller controls the movement of the substrate stage such that a setting

10 distance for a first shot region to be scanned and exposed upon a change in row to which a shot region of an exposure object belongs is set longer than a setting distance for other shot regions.

In a preferred embodiment, the controller

15 controls the continuous movement of the substrate stage in accordance with a common setting distance for shot regions other than the first shot region to be scanned and exposed among a plurality of shot regions belonging to one row.

20 In a preferred embodiment, the controller controls the continuous movement of the substrate stage in accordance with a setting distance determined for each row to which a plurality of shot regions belong.

In a preferred embodiment, the setting distance

25 is determined on the basis of a setting time until synchronization error between the master stage and the substrate stage falls within an allowable range after

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the substrate stage is accelerated up to a scan speed
for scanning exposure.

According to the another aspect of the present
invention, the foregoing object is attained by

5   providing a scanning exposure apparatus for
transferring a pattern of a master onto each shot
region while synchronously scanning the master and a
substrate on which a plurality of shot regions are
arrayed, comprising: a master stage for moving the

10   master; a substrate stage for moving the substrate; and
a controller for controlling movement of the substrate
stage for a plurality of shot regions so as to assure a
setting distance serving as a distance for scanning and
moving the substrate stage at a uniform velocity in

15   order to guarantee that synchronization error between
the master stage and the substrate stage falls within
an allowable range after the substrate stage is
accelerated up to a scan speed for scanning exposure,
wherein the controller controls movement of the

20   substrate stage in accordance with a setting distance
determined for each row to which a plurality of shot
regions belong.

In a preferred embodiment, the setting distance
is determined on the basis of a setting time until

25   synchronization error between the master stage and the
substrate stage falls within an allowable range after
the substrate stage is accelerated up to a scan speed

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for scanning exposure.

According to the another aspect of the present invention, the foregoing object is attained by providing a scanning exposure method of transferring a pattern of a master onto each shot region while synchronously scanning the master and a substrate on which a plurality of shot regions are arrayed, comprising: the control step of controlling movement of a substrate stage for a plurality of shot regions so as

10   to assure a setting distance serving as a distance for scanning and moving the substrate stage at a uniform velocity in order to guarantee that synchronization error between a master stage and the substrate stage falls within an allowable range after the substrate

15   stage is accelerated up to a scan speed for scanning exposure, wherein in the control step, the movement of the substrate stage is controlled such that a setting distance for a first shot region to be scanned and exposed upon a change in row to which a shot region of

20   an exposure object belongs is set longer than a setting distance for other shot regions.

In a preferred embodiment, in the control step, the continuous movement of the substrate stage is controlled in accordance with a common setting distance

25   for shot regions other than the first shot region to be scanned and exposed among a plurality of shot regions belonging to one row.

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In a preferred embodiment, in the control step, the continuous movement of the substrate stage is controlled in accordance with a setting distance determined for each row to which a plurality of shot

5   regions belong.

In a preferred embodiment, the setting distance is determined on the basis of a setting time until synchronization error between the master stage and the substrate stage falls within an allowable range after

10   the substrate stage is accelerated up to a scan speed for scanning exposure.

According to the another aspect of the present invention, the foregoing object is attained by providing a scanning exposure method of transferring a

15   pattern of a master onto each shot region while synchronously scanning the master and a substrate on which a plurality of shot regions are arrayed, comprising: the control step of controlling movement of a substrate stage for a plurality of shot regions so as

20   to assure a setting distance serving as a distance for scanning and moving the substrate stage at a uniform velocity in order to guarantee that synchronization error between a master stage and the substrate stage falls within an allowable range after the substrate

25   stage is accelerated up to a scan speed for scanning exposure, wherein in the control step, movement of the substrate stage is controlled in accordance with a

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setting distance determined for each row to which a plurality of shot regions belong.

In a preferred embodiment, the setting distance is determined on the basis of a setting time until synchronization error between the master stage and the substrate stage falls within an allowable range after the substrate stage is accelerated up to a scan speed for scanning exposure.

According to the another aspect of the present invention, the foregoing object is attained by providing a semiconductor device manufacturing method comprising the steps of: installing manufacturing apparatuses for various processes including the above scanning exposure apparatus in a semiconductor

15 manufacturing factory; and manufacturing a semiconductor device in a plurality of processes by using the manufacturing apparatuses.

According to the preferred embodiment of the present invention, the method may comprises the steps

20 of: connecting the manufacturing apparatuses by a local area network; and communicating information about at least one of the manufacturing apparatuses between the local area network and an external network of the semiconductor manufacturing factory.

25 According to the preferred embodiment of the present invention, the method may comprises the step of acquiring maintenance information of the scanning

exposure apparatus by accessing a database provided by a vendor or user of the scanning exposure apparatus via the external network.

According to the another aspect of the present invention, the foregoing object is attained by providing a semiconductor manufacturing factory comprising: manufacturing apparatuses for various processes including the above scanning exposure apparatus; a local area network for connecting the

10 manufacturing apparatuses; and a gateway for allowing the local area network to access an external network of the factory, wherein information about at least one of the manufacturing apparatuses is communicated.

According to the another aspect of the present invention, the foregoing object is attained by providing a maintenance method for the above scanning exposure apparatus that is installed in a semiconductor manufacturing factory, comprising the steps of: causing a vendor or user of the scanning exposure apparatus to

20 provide a maintenance database connected to an external network of the semiconductor manufacturing factory; authenticating access from the semiconductor manufacturing factory to the maintenance database via the external network; and transmitting maintenance

25 information accumulated in the maintenance database to the semiconductor manufacturing factory via the external network.

According to the preferred embodiment of the present invention, the apparatus may comprises: a display; a network interface; and a computer for executing network software, wherein maintenance

5   information of the scanning exposure apparatus can be communicated via a computer network.

In a preferred embodiment, the network software is connected to an external network of a factory where the scanning exposure apparatus is installed, provides

10 on the display a user interface for accessing a maintenance database provided by a vendor or user of the scanning exposure apparatus, and enables obtaining information from the database via the external network.

According to the present invention, the foregoing

15 object is attained by providing a semiconductor device manufacturing method comprising the steps of: installing manufacturing apparatuses for various processes including the above scanning exposure apparatus in a semiconductor manufacturing factory; and

20 manufacturing a semiconductor device in a plurality of processes by using the manufacturing apparatuses.

According to the preferred embodiment of the present invention, the method may comprises the steps of: connecting the manufacturing apparatuses by a local

25 area network; and communicating information about at least one of the manufacturing apparatuses between the local area network and an external network of the

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semiconductor manufacturing factory.

According to the preferred embodiment of the present invention, the method may comprises the step of acquiring maintenance information of the scanning exposure apparatus by accessing a database provided by a vendor or user of the scanning exposure apparatus via the external network.

According to the another aspect of the present invention, the foregoing object is attained by

10 providing a semiconductor manufacturing factory comprising: manufacturing apparatuses for various processes including the above scanning exposure apparatus; a local area network for connecting the manufacturing apparatuses; and a gateway for allowing

15 the local area network to access an external network of the factory, wherein information about at least one of the manufacturing apparatuses is communicated.

According to the another aspect of the present invention, the foregoing object is attained by

20 providing a maintenance method for the above scanning exposure apparatus that is installed in a semiconductor manufacturing factory, comprising the steps of: causing a vendor or user of the scanning exposure apparatus to provide a maintenance database connected to an external

25 network of the semiconductor manufacturing factory; authenticating access from the semiconductor manufacturing factory to the maintenance database via

the external network; and transmitting maintenance
information accumulated in the maintenance database to
the semiconductor manufacturing factory via the
external network.

5   According to the preferred embodiment of the
present invention, the apparatus may comprises: a
display; a network interface; and a computer for
executing network software, wherein maintenance
information of the scanning exposure apparatus can be
10   communicated via a computer network.

In a preferred embodiment, the network software
is connected to an external network of a factory where
the scanning exposure apparatus is installed, provides
on the display a user interface for accessing a
15   maintenance database provided by a vendor or user of
the scanning exposure apparatus, and enables obtaining
information from the database via the external network.

Other features and advantages of the present
invention will be apparent from the following
20   description taken in conjunction with the accompanying
drawings, in which like reference characters designate
the same or similar parts throughout the figures
thereof.

25   BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated
in and constitute a part of the specification,

illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a schematic view showing a scanning

5   exposure apparatus according to a preferred embodiment of the present invention;

Fig. 2 is a graph showing the relationship between speed and time when a wafer stage is scanned and moved in an exposure axis (Y-axis);

10   Fig. 3 is a waveform chart showing a change in synchronization error of the wafer stage as a function of time;

Fig. 4 is a plan view for explaining a method of adapting a synchronization setting distance in a change

15   in row of shots;

Fig. 5 is a plan view showing a given shot layout;

Fig. 6 is a conceptual view of a semiconductor device production system using the apparatus of the

20   present invention when viewed from a given angle;

Fig. 7 is a conceptual view of a semiconductor device production system using the apparatus of the present invention when viewed from another angle;

Fig. 8 is a view showing the detailed example of

25   a user interface;

Fig. 9 is a view for explaining the flow of a device manufacturing process; and

Fig. 10 is a view for explaining a wafer process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First Embodiment)

5   The first embodiment of the present invention
will be described below with reference to the
accompanying drawings. This embodiment will exemplify a
projection exposure apparatus of a step-and-scan scheme
for sequentially transferring and exposing a pattern
10   formed on a reticle onto the shot regions on a wafer by
scanning a reticle serving as a master and a wafer
serving as a substrate in synchronism with a projection
optical system.

Fig. 1 shows the schematic arrangement of the
15   projection exposure apparatus according to this
embodiment. Referring to Fig. 1, illumination light IL
emitted from an illumination optical system SL
including a light source, a variable field stop for
shaping the illumination light into a slit, and a
20   condenser lens illuminates a slit-like illumination
region on a reticle R with a uniform illuminance
profile. A pattern on the reticle R within the
illumination region is inverted and reduced at a
projection magnification α (e.g., $\alpha = 1/4$) through a
25   projection optical system UL. The resultant image is
projected and exposed onto a slit-like irradiation
field on a wafer W. Examples of the illumination light

IL are a KrF excimer laser beam, ArF excimer laser beam, and the bright lines (e.g., g- and i-lines) of the ultraviolet range of an ultra-high-pressure mercury lamp.

The reticle R is placed on a reticle stage 7. The reticle stage 7 finely and two-dimensionally moves the reticle R in a plane perpendicular to the optical axis of the projection optical system UL, thereby positioning the reticle R. At the same time, the

10   reticle stage 7 scans the reticle R in synchronism with a wafer stage 1. The reticle stage 7 has a scan-direction stroke enough to make the entire surface of the pattern region of the reticle R cross at least the slit-like illumination region. A mirror 8 for

15   reflecting a laser beam emitted from a laser interferometer 28 is fixed at the end portion of the reticle stage 7. The position of the reticle stage 7 is always monitored by the laser interferometer 28. The position information of the reticle stage 7 from the

20   laser interferometer 28 is supplied to a controller 21. The controller 21 controls the position and speed of the reticle stage 7 through a reticle stage driver 26 on the basis of the position information.

The wafer W is placed on the chuck of the wafer stage 1. The wafer stage 1 performs step-and-scan operation of repeating stepping operation to each shot region on the wafer W and scan operation. The

controller 21 controls the wafer stage 1 to move the wafer in a vertical direction (Z direction) and tilt direction. A mirror 3 for reflecting a laser beam emitted from a laser interferometer 27 is mounted at

5   the end portion of the wafer stage 1. The position of the wafer stage 1 is always monitored by the laser interferometer 27. The controller 21 controls the position and speed of the wafer stage 1 as in the control for the reticle stage 7.

10   Assume that a Z-axis is defined as a direction parallel to the optical axis of the projection optical system UL, an X-axis is defined as an axis parallel to the drawing surface in the plane perpendicular to the axis of the projection optical system UL, and a Y-axis

15   is defined as an axis perpendicular to the drawing surface.

First of all, the setting of drive target values of the wafer stage 1 and reticle stage 7 will be described below. The laser interferometer 27 detects

20   the position of the wafer stage 1 by using the mirror 3. The wafer stage 1 is driven in the X direction, Y direction, and rotational direction (θ direction) on the basis of the detected position. Since a triaxial laser source is mounted in the laser interferometer 27,

25   drive amounts in the θ and tilt directions can also be detected. The laser interferometer 27 detects position information every predetermined time interval and

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supplies the position information to the controller 21 which systematically controls the operation of the entire apparatus. The controller 21 outputs a drive instruction to the wafer stage driver 25 every

5 predetermined time interval on the basis of the position information, thereby driving the wafer stage 1 to the target position.

The laser interferometer 28 detects the position of the reticle stage 7 by using the mirror 8 in the

10 same manner as in the wafer stage 1. The controller 21 calculates a drive amount on the basis of the detected position. The controller 21 outputs a drive instruction to the reticle stage driver 26, thereby driving the reticle stage 7 to the target position.

15 In this embodiment, in scanning exposure, the wafer W is scanned in the -Y direction at a speed Vw in synchronism with scanning the reticle R in the +Y direction at a speed of, e.g., Vr. The ratio (Vw/Vr) of the scan speed Vw to the scan speed Vr accurately

20 matches the projection magnification α of the projection optical system UL for exposure from the reticle R to the wafer W. This makes it possible to accurately transfer the pattern on the reticle R onto each shot region on the wafer W. Referring to Fig. 1;-

25 reference numeral 2 denotes a linear motor; 4, a wafer stage surface plate on which the wafer stage 1 and a linear motor for driving the wafer stage 1 are mounted;

6, a lens barrel surface plate for supporting the projection optical system UL; 9, a reticle stage surface plate; and 10, an outer cylinder.

The scanning exposure method of this embodiment
5 will be described below. Operations for scanning exposure include, e.g., stepping, stopping, and aligning operations for the wafer stage 1 and reticle stage 7 along with exposure, scanning required for setting before the start of exposure,
10 deceleration/acceleration scanning, turn-on/turn-off operation of a light source, and scanning exposure operation. In the scanning exposure, the scanning required for setting before the start of exposure is a factor for influencing actual exposure and
15 synchronization accuracy between the wafer stage 1 and reticle stage 7 in exposure. The scanning required for the setting is scanning required until the vibration generated by the wafer stage 1 is attenuated to a negligible state for exposure. The distance required
20 for the setting, i.e., the setting distance is determined by the setting time and scan speed determined by the performance of the stage.

Fig. 2 is a view showing the driven stage of the wafer stage 1 in the scan axis (Y-axis) upon scanning
25 exposure. In scanning exposure, generally, the wafer stage is accelerated up to a predetermined exposure speed (interval L1). The wafer stage is moved at a

uniform velocity by the setting distance (interval L2).

When the wafer stage 1 is set, exposure is done

(interval L3). Stepping operation to the next shot in

the non-scan axis (X-axis) is performed upon completing

5   the exposure. At the same time, the wafer stage 1 is

moved at a uniform velocity in the scan axis (Y-axis)

by a distance required for setting the wafer stage 1

before the next exposure is started (interval L4). The

wafer stage 1 is then decelerated (interval L5). Upon

10 completing movement in the scan axis (Y-axis), the scan

direction is reversed to start scanning for the next

shot. The series of operations described above are

repeated to perform exposure in the order of layout of

shots defined on the wafer W.

15 In exposure for adjacent shots, the wafer stage 1

is moved at a uniform velocity by a distance required

for setting at the end of exposure. The wafer stage 1

can be moved beforehand by the setting distance

required before the start of exposure of the next shot.

20 Exposure can be done without interrupting scanning in

moving operation between the shots. The setting

distance L2 is calculated as the product (L2 = Vw x Tw)

of the exposure speed Vw and the setting time Tw of the

wafer stage. At present, since the setting time Tw is

25 always constant regardless of conditions, a time

required for moving the wafer stage 1 by the distance

L2 is constant regardless of the exposure speed.

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Synchronization error required to calculate the setting time Tw will be described below.

The controller 21 calculates a target coordinate position YWN of the wafer stage 1 which changes over

5 time in scanning exposure and a difference ΔYW (= YWN - YW) between the target coordinate position YWN and a current coordinate position YW supplied from the laser interferometer 27. The controller 21 causes the wafer stage driver 25 to drive the wafer stage 1 in

10 accordance with the difference ΔYW. The controller 21 defines, as the target position of the reticle stage which reflects an offset from the target value of the wafer stage, a value (= YRN - ΔYW/α) obtained by subtracting from the target coordinate position YRN of

15 the reticle stage 7 the product obtained by multiplying a reciprocal (1/α) of the projection magnification α of the illumination optical system SL in exposure from the reticle R to the wafer W by the difference ΔYW. The controller 21 reflects on the reticle stage the

20 offset generated on the wafer stage side.

The controller 21 has an arithmetic unit 23 for calculating the difference ΔYR between the target value (YRN - ΔYW/α) and the coordinate position YR of the stage 7 supplied from the laser interferometer 28:

25 ΔYR = YRN - ΔYW/α - YR

This difference ΔYR is the position offset of the reticle stage 7 with respect to the target position of

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the reticle stage 7 corresponding to the actual

position of the wafer stage 1. That is, the difference

ΔYR is the synchronization error in the scan direction.

In obtaining the setting time required for

5   setting the wafer stage 1, the arithmetic unit 23 must

calculate and monitor the synchronization error ΔYR

every predetermined time interval on the basis of the

outputs from the laser interferometers 27 and 28. A

method of determining the setting time based on the

10   synchronization error ΔYR will be described with

reference to Fig. 3.

Fig. 3 shows a change in synchronization error Δ

YR from the instant when acceleration of the wafer

stage 1 is complete. More specifically, Fig. 3 shows a

15   change in synchronization error ΔYR as a function of

time when the wafer stage 1 is moved at a uniform

velocity. The synchronization error ΔYR decreases to

converge the vibration with the lapse of time T. The

synchronization setting time is obtained as follows.

20   The laser interferometers 27 and 28 and the

synchronization error arithmetic unit 23 measure the

synchronization error ΔYR every predetermined time

interval at the end of acceleration of the wafer stage

1 and determine the time until the absolute value of

25   the synchronization error ΔYR falls within an allowable

range ε. In Fig. 3, TA is the synchronization setting

time. The allowable value ε is determined by

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performance of the apparatus and hardware factors. In this case, the synchronization setting distance is a distance obtained by multiplying the synchronization setting time by the scan speed.

The exposure procedures for a plurality of shots arrayed in a matrix on the wafer according to a preferred embodiment of the present invention will be described with reference to Fig. 4. Fig. 4 is a view when paying attention to a change in row of exposure

10   objects as a plurality of shots in exposure according to the step-and-scan scheme.

Fig. 4 shows a state wherein exposure is performed by setting the synchronization setting distance of the first shot to be scanned and exposed

15   upon a change in row to be longer than the synchronization setting distance of the remaining shots upon a change in row of the exposure objects. A distance D in Fig. 4 is a distance by which the wafer stage 1 is accelerated until it reaches the exposure

20   scan speed. Distances L1 and L1' (L1 < L1') represent the synchronization setting distances until the synchronization error ΔYR falls within the allowable range ε upon accelerating the wafer stage 1 up to the scan speed. L1 is the synchronization setting distance

25   without any change in row, while L1' is the synchronization setting distance of the first shot upon a change in row.

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The stepping amount of the wafer stage 1 upon a change in row is larger than that without any change in row. The vibration of the wafer stage 1 upon acceleration is larger than that generated by exposing

5   parallel shots (shots having the same Y-coordinate, i.e., shots arrayed in a direction perpendicular to the scan direction in scanning exposure) without any change in row. As a result, when the first shot scanned and exposed upon a change in row is to be exposed, a longer

10   synchronization setting distance than the synchronization setting distance required for exposing parallel shots without any change in row is required. In the current exposure apparatus, since the same setting distance is designated for all the shots, the

15   distance for properly setting the wafer stage 1 for all the shots, i.e., a value as the sum of the margin and the longest setting distance required for a change in row is used.

In the scanning exposure method of the preferred

20   embodiment of the present invention, to reduce an unnecessary synchronization setting distance, L1 is used as the setting distance for the parallel shots without any change in row, such as shots S1 and S2. For the first shot S3 to be scanned and exposed upon a

25   change in row, the setting distance is switched to a longer setting distance L1' than the synchronization setting distance required for the shots S1 and S2,

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thereby starting the exposure. The synchronization setting distances L1 and L1' are obtained as follows. The controller 21 loads the synchronization setting times about parallel shots without any change in row and the first shot to be scanned and exposed upon a change in row. The controller 21 multiplies the scan speed in exposure with the loaded synchronization setting times. Each synchronization setting time stored in a storage unit 24 can be obtained by measuring a synchronization setting time a plurality of number of times beforehand and adding a variance to the average value of the measured values. The synchronization setting time increases in proportion to the scan speed (scanning exposure speed) in exposure. For this reason, the synchronization setting times are measured at, e.g., 100 mm/sec, 150 mm/sec, 200 mm/sec, and 250 mm/sec. Scanning exposure at the actual scanning exposure speed of 160 mm/sec is performed using the synchronization setting time measured at 200 mm/sec, thereby performing exposure with an optimized synchronization setting distance.

Fig. 5 is a view showing a wafer layout. The thrust of a linear motor serving as a driving source for the wafer stage 1 is nonuniform depending on positions, and a reaction force of a damper which supports the wafer stage surface plate changes depending on the position on the wafer stage 1. The

synchronization setting time changes depending on the driving coordinates. For this reason, when the synchronization setting time is strictly measured, the measured synchronization setting time changes depending

5 on shots in Fig. 5. For this reason, there can be a method of performing exposure by measuring the synchronization setting time for each shot on the layout in Fig. 5 and switching the synchronization setting distance for each shot in scanning exposure.

10 In practice, when the synchronization setting distance changes for each shot, stepping operation in the scan direction (Y direction) must be done in alignment to the scan start position, and the setting time is inevitably prolonged. The setting time is

15 determined for each row (row 1 to row 5) and each shot in Fig. 5, and the setting distance is obtained on the basis of the setting time. Stepping operation to the scan start position in exposing the parallel shots in order need not be performed. The total time of the

20 setting times required for exposing all the shots on the wafer can be shortened to improve the throughput. In this case, since the synchronization setting time changes due to the exposure speed, the synchronization setting times measured at the plurality of exposure

25 speeds are stored in the storage unit 24.

It is preferable to combine the method of determining the synchronization setting time or

synchronization setting distance described with reference to Fig. 4 with the method of determining the synchronization setting time or synchronization setting distance described with reference to Fig. 5. More

5 specifically, it is preferable that the synchronization setting time or synchronization setting distance for a shot upon a change in row be determined for each row (for each parallel shot), and the synchronization setting time or synchronization setting distance for

10 the first shot scanned and exposed upon a change in row be determined for each row (for each parallel shot).

(Second Embodiment)

The second embodiment of the present invention will exemplify a case in which a setting distance is

15 obtained on the basis of a scan speed or scan acceleration. In this embodiment, a setting time corresponding to a change in scan speed or scan acceleration is measured. The measurement result is held in a storage unit 24 or the like in Fig. 1. A

20 controller 21 can load the measurement result (setting time) from the storage unit 24 or the like. The setting time to be stored in the storage unit can be obtained by measuring the setting time a plurality of number of times and adding a variance to the measured setting

25 times.

To measure synchronization accuracy, for example, the scan speed and scan acceleration are changed every

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predetermined time interval, and the synchronization

setting times measured under the respective conditions

are held as a table in the storage unit 24 or the like

in Fig. 1. In scanning exposure, the controller 21

5   obtains an optimal synchronization time in the table in

accordance with the scan speed. If no optimal

synchronization setting time corresponding to the scan

speed is present in the table, a synchronization

setting time can be calculated by linear interpolation

10   using two approximate values in the table. Using the

resultant setting time, the setting distance is

obtained by the product of the setting time and scan

speed. If the synchronization setting time is based on

the scan acceleration, the setting distance is

15   calculated by the product of the scan speed obtained by

integrating the scan acceleration and the setting time

based on the above setting time measurement result

corresponding to the change in scan acceleration.

A countermeasure for the influence of stepping

20   operation before scanning exposure on the

synchronization accuracy will be described below. The

influence of stepping operation immediately before

scanning exposure on the synchronization accuracy

depends not only on the stepping speed or acceleration

25   but also the length of the stepping operation stroke.

For example, stepping operation with a relatively

long stroke in the X-axis is performed to the start

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position of the first shot. The synchronization

accuracy is poorer in the first shot than in other

shots. In this case, only the synchronization setting

distance for the first shot is made longer than that of

5   other shots. A shorter synchronization setting distance

than the synchronization setting distance for the first

shot is set for other shots.

(Third Embodiment)

In each embodiment described above, the

10   synchronization setting time is influenced even if

conditions such as floor vibration change. It is

preferable that the synchronization setting time be

recalculated depending on the installation position of

the apparatus. In consideration of the change in the

15   state of the apparatus or floor over time, the

synchronization setting time is preferably and

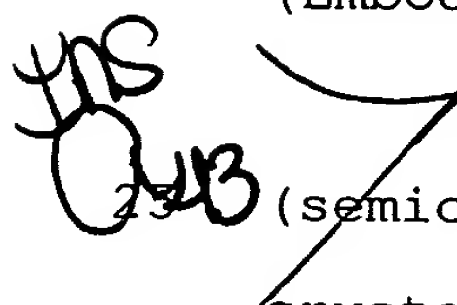periodically measured.

(Fourth Embodiment)

A case wherein an exposure apparatus has a

20   learning function will be described as the fourth

embodiment of the present invention. In the exposure

apparatus of this embodiment, synchronization setting

times measured under a plurality of conditions

beforehand are held in a file in a storage medium such

25   as a storage unit 24 or the like in Fig. 1 or in a

nonvolatile memory. The stored synchronization setting

times are selectively used in accordance with the

exposure conditions and hard factors. Every time

scanning exposure is performed for each shot region on

a wafer in accordance with the stored synchronization

setting time, the synchronization setting time for each

5   shot is actually measured using laser interferometers

27 and 28 and an arithmetic unit 23. A controller 21

optimizes the synchronization setting time on the basis

of the measured synchronization setting time.

As the measured synchronization setting times,

10   values corresponding to all the shots on the wafer are

stored. These stored values undergo statistical

processing. If shot layouts are identical, the optimal

synchronization setting time calculated by the actual

synchronization setting time is set for the next wafer,

15   thereby performing scanning exposure.

By this learning function, the synchronization

setting distance is optimized any time on the basis of

the actual synchronization setting time measured for

each exposed shot in the exposure apparatus of this

20   embodiment. Therefore, the setting distance is

suppressed to a minimum distance, and the throughput is

improved.

(Embodiment of Semiconductor Production System)

A production system for a semiconductor device

(semiconductor chip such as an IC or LSI, liquid

crystal panel, CCD, thin-film magnetic head,

micromachine, or the like) will be exemplified. A

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trouble remedy or periodic maintenance of a
manufacturing apparatus installed in a semiconductor
manufacturing factory, or maintenance service such as
software distribution is performed by using a computer
5   network outside the manufacturing factory.

Fig. 6 shows the overall system cut out at a
given angle. In Fig. 6, reference numeral 101 denotes a
business office of a vendor (apparatus supply
manufacturer) which provides a semiconductor device
10   manufacturing apparatus. Assumed examples of the
manufacturing apparatus are semiconductor manufacturing
apparatuses for various processes used in a
semiconductor manufacturing factory, such as
pre-process apparatuses (lithography apparatus
15   including an exposure apparatus, resist processing
apparatus, and etching apparatus, annealing apparatus,
film formation apparatus, planarization apparatus, and
the like) and post-process apparatuses (assembly
apparatus, inspection apparatus, and the like). The
20   business office 101 comprises a host management system
108 for providing a maintenance database for the
manufacturing apparatus, a plurality of operation
terminal computers 110, and a LAN (Local Area Network)
109 which connects the host management system 108 and
25   computers 110 to construct an intranet. The host
management system 108 has a gateway for connecting the
LAN 109 to Internet 105 as an external network of the

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business office, and a security function for limiting external accesses.

Reference numerals 102 to 104 denote manufacturing factories of the semiconductor

5 manufacturer as users of manufacturing apparatuses. The manufacturing factories 102 to 104 may belong to different manufacturers or the same manufacturer (pre-process factory, post-process factory, and the like). Each of the factories 102 to 104 is equipped

10 with a plurality of manufacturing apparatuses 106, a LAN (Local Area Network) 111 which connects these apparatuses 106 to construct an intranet, and a host management system 107 serving as a monitoring apparatus for monitoring the operation status of each

15 manufacturing apparatus 106. The host management system 107 in each of the factories 102 to 104 has a gateway for connecting the LAN 111 in the factory to the Internet 105 as an external network of the factory. Each factory can access the host management system 108

20 of the vendor 101 from the LAN 111 via the Internet 105. The security function of the host management system 108 authorizes access of only a limited user. More specifically, the factory notifies the vender via the Internet 105 of status information (e.g., the symptom

25 of a manufacturing apparatus in trouble) representing the operation status of each manufacturing apparatus 106. The factory can receive, from the vender, response

information (e.g., information designating a remedy against the trouble, or remedy software or data) corresponding to the notification, or maintenance information such as the latest software or help

5 information. Data communication between the factories 102 to 104 and the vender 101 and data communication via the LAN 111 in each factory adopt a communication protocol (TCP/IP) generally used in the Internet. Instead of using the Internet as an external network of

10 the factory, a dedicated-line network (e.g., ISDN) having high security which inhibits access of a third party can be adopted. It is also possible that the user constructs a database in addition to one provided by the vendor and sets the database on an external network

15 and that the host management system authorizes access to the database from a plurality of user factories.

Fig. 7 is a view showing the concept of the overall system of this embodiment that is cut out at a different angle from Fig. 6. In the above example, a

20 plurality of user factories having manufacturing apparatuses and the management system of the manufacturing apparatus vendor are connected via an external network, and production management of each factory or information of at least one manufacturing

25 apparatus is communicated via the external network. In the example of Fig. 7, a factory having manufacturing apparatuses of a plurality of vendors, and the

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management systems of the vendors for these
manufacturing apparatuses are connected via the
external network of the factory, and maintenance
information of each manufacturing apparatus is

5   communicated. In Fig. 7, reference numeral 201 denotes
a manufacturing factory of a manufacturing apparatus
user (semiconductor device manufacturer) where
manufacturing apparatuses for various processes, e.g.,
an exposure apparatus 202, resist processing apparatus

10   203, and film formation apparatus 204 are installed in
the manufacturing line of the factory. Fig. 7 shows
only one manufacturing factory 201, but a plurality of
factories are networked in practice. The respective
apparatuses in the factory are connected to a LAN 206

15   to construct an intranet, and a host management system
205 manages the operation of the manufacturing line.

The business offices of vendors (apparatus supply
manufacturers) such as an exposure apparatus
manufacturer 210, resist processing apparatus

20   manufacturer 220, and film formation apparatus
manufacturer 230 comprise host management systems 211,
221, and 231 for executing remote maintenance for the
supplied apparatuses. Each host management system has a
maintenance database and a gateway for an external

25   network, as described above. The host management system
205 for managing the apparatuses in the manufacturing
factory of the user, and the management systems 211,

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221, and 231 of the vendors for the respective apparatuses are connected via the Internet or dedicated-line network serving as an external network 200. If a trouble occurs in any one of a series of

5 manufacturing apparatuses along the manufacturing line in this system, the operation of the manufacturing line stops. This trouble can be quickly solved by remote maintenance from the vendor of the apparatus in trouble via the Internet 200. This can minimize the stop of the

10 manufacturing line.

Each manufacturing apparatus in the semiconductor manufacturing factory comprises a display, a network interface, and a computer for executing network access software and apparatus operating software which are

15 stored in a storage device. The storage device is a built-in memory, hard disk, or network file server. The network access software includes a dedicated or general-purpose web browser, and provides a user interface having a window as shown in Fig. 8 on the

20 display. While referring to this window, the operator who manages manufacturing apparatuses in each factory inputs, in input items on the windows, pieces of information such as a type 401 of manufacturing apparatus, a serial number 402, a subject 403 of

25 trouble, an occurrence date 404, a degree 405 of urgency, a symptom 406, a remedy 407, and a progress 408. The pieces of input information are transmitted to

the maintenance database via the Internet, and appropriate maintenance information is sent back from the maintenance database and displayed on the display. The user interface provided by the web browser realizes

5   hyperlink functions 410 to 412, as shown in Fig. 8. This allows the operator to access detailed information of each item, receive the latest-version software to be used for a manufacturing apparatus from a software library provided by a vendor, and receive an operation

10   guide (help information) as a reference for the operator in the factory. Maintenance information provided by the maintenance database includes information about the information concerning the present invention described above. The software library

15   also provides the latest-version software for realizing the present invention.

A semiconductor device manufacturing process using the above-described production system will be explained. Fig. 9 shows the flow of the whole

20   manufacturing process of the semiconductor device. In step 1 (circuit design), a semiconductor device circuit is designed. In step 2 (mask formation), a mask on which the design circuit pattern is formed is prepared. In step 3 (wafer manufacture), a wafer is manufactured

25   using a material such as silicon. In step 4 (wafer process) called a pre-process, an actual circuit is formed on the wafer by lithography using a prepared

mask and the wafer. Step 5 (assembly) called a

post-process is the step of forming a semiconductor

chip by using the wafer manufactured in step 4, and

includes an assembly process (dicing and bonding) and

5   packaging process (chip encapsulation). In step 6

(inspection), inspections such as the operation

confirmation test and durability test of the

semiconductor device manufactured in step 5 are

conducted. After these steps, the semiconductor device

10   is completed and shipped (step 7). The pre-process and

post-process are performed in separate dedicated

factories, and maintenance is done for each of the

factories by the above-described remote maintenance

system. Information for production management and

15   apparatus maintenance is communicated between the

pre-process factory and the post-process factory via

the Internet or dedicated-line network.

Fig. 10 shows the detailed flow of the wafer

process. In step 11 (oxidation), the wafer surface is

20   oxidized. In step 12 (CVD), an insulating film is

formed on the wafer surface. In step 13 (electrode

formation), an electrode is formed on the wafer by

vapor deposition. In step 14 (ion implantation), ions

are implanted in the wafer. In step 15 (resist

25   processing), a photosensitive agent is applied to the

wafer. In step 16 (exposure), the above-mentioned

scanning exposure apparatus bakes and exposes the

circuit pattern of a mask on the wafer. In step 17
(developing), the exposed wafer is developed. In step
18 (etching), the resist is etched except for the
developed resist image. In step 19 (resist removal), an
5   unnecessary resist after etching is removed. These
steps are repeated to form multiple circuit patterns on
the wafer. A manufacturing apparatus used in each step
undergoes maintenance by the remote maintenance system,
which prevents a trouble in advance. Even if a trouble
10 occurs, the manufacturing apparatus can be quickly
recovered. The productivity of the semiconductor device
can be increased in comparison with the prior art.

According to the present invention, the setting
distance serving as a distance for moving the substrate
15 stage at a uniform velocity is set uniform in order to
guarantee that the synchronization error between the
master stage and substrate stage falls within the
allowable range. Therefore, the total time required for
maintaining the synchronization accuracy can be shorted,
20 and the throughput can be improved.

As many apparently widely different embodiments
of the present invention can be made without departing
from the spirit and scope thereof, it is to be
understood that the invention is not limited to the
25 specific embodiments thereof except as defined in the
appended claims.